

NATIONAL TRANSPORTATION SAFETY BOARD
Vehicle Recorder Division
Washington, D.C. 20594

November 24, 2017

Cockpit Displays – Recorded Flight Data

Specialist's Factual Report
By Bill Tuccio, Ph.D.

1. EVENT SUMMARY

Location: San Antonio, Texas
Date: January 25, 2017
Aircraft: Cirrus SR22
Registration: N401SC
Operator: Private
NTSB Number: CEN17FA084

On January 25, 2017, about 1540 central standard time, a Cirrus Design SR22 airplane, N401SC, was substantially damaged during an in-flight collision with trees and terrain about one mile southeast of the Stinson Municipal Airport (SSF), San Antonio, Texas. The pilot was fatally injured. The airplane was registered to and operated by the pilot under the provisions of 14 *Code of Federal Regulations* Part 91 as a personal flight. Visual meteorological conditions prevailed for the flight, which was not operated on a flight plan. The flight originated from the San Antonio International Airport (SAT) about 1532.

2. RECORDED FLIGHT DATA GROUP

A recorded flight data group was not convened.

3. DETAILS OF INVESTIGATION

The National Transportation Safety Board (NTSB) Vehicle Recorder Division received the following electronic devices:

Recorder Manufacturer/Model: **Avidyne Primary Flight Display (PFD)**
Recorder Serial Number: **20319305**

Recorder Manufacturer/Model: **Avidyne Multifunction Display (MFD) card**
Recorder Serial Number: **Not applicable**

3.1. Avidyne Primary Flight Display (PFD) Description

The PFD unit includes a solid-state Air Data and Attitude Heading Reference System (ADAHRS) and displays aircraft parameter data including altitude, airspeed, attitude, vertical speed, and heading. The PFD unit has external pitot/static inputs for altitude, airspeed, and vertical speed information. The PFD has a data logging function, which is used by the manufacturer for maintenance and diagnostics. Maintenance and diagnostic information

recording consists of system information, event data, and flight data are recorded to non-volatile memory.¹

The PFD samples and stores several data streams in a sequential fashion; when the recording limit of the PFD is reached, the oldest record is dropped and a new record is added. Data from the Attitude/Heading Reference System (AHRS) is recorded at a rate of 5 Hz. Air data information such as pressure altitude, indicated airspeed, and vertical speed are recorded at 1 Hz. Global Positioning System (GPS) and navigation display and setting data are recorded at a rate of 0.25 Hz, and information about pilot settings of heading, altitude, and vertical speed references are recorded when changes are made.

3.1.1. PFD Data Recovery

The PFD was severely damaged in the event, as shown in figure 1 (front) and figure 2 (back). The internal circuit board containing two non-volatile memory chips was located. The board was placed in a surrogate PFD, but the unit would not start properly. The two non-volatile memory chips—in locations U1101 and U1102—were removed from the board as shown in figure 3. The chips were read out using a chip programmer and decoded.

Figure 1. Damaged exterior of PFD - front.



¹ Non-volatile memory is semiconductor memory that does not require external power for data retention.

Figure 2. Damaged exterior of PFD – back.



Figure 3. Internal circuit board with non-volatile memory chips removed.



3.1.2. PFD Data Description

The decoded PFD recording contained 43 power cycles, four of which were consistent with prior flights; the oldest being from December 28, 2016, and the most recent being the accident flight. Only the accident flight is considered in this report.

3.1.3. PFD Engineering Units Conversions

Conversion of chip-level recovered PFD data to engineering units is performed using conversions developed by the NTSB with support from Avidyne. Conversions conform to the Safety Board's standard sign convention that climbing right turns are positive (CRT=+).²

Appendix A lists the PFD parameters verified and provided in this report.

3.2. Avidyne Multi-Function Display (MFD) Description

The MFD unit can display the pilot checklist, terrain/map information, approach chart information and other aircraft/operational information depending on the specific configuration and options that are installed. One of the options available is a display of comprehensive engine monitoring and performance data.

Each MFD contains a compact flash (CF) memory card located in a slot on the side of the unit. This memory card contains all the software that the MFD needs to operate. Additionally, this card contains all the checklist, approach charts, and map information the unit uses to generate the various cockpit displays.

During operation, the MFD display receives information from several other units that are installed on the aircraft. Specifically, the MFD receives GPS position, time, and track data from the aircraft's GPS receiver. The MFD may also receive information from the aircraft concerning altitude, engine and electrical system parameters, and outside air temperature. This data is also stored on the unit's CF memory card.

The MFD generates new data files for each MFD power-on cycle. The oldest file is dropped and replaced by a new recording once the storage limit has been reached. MFD data are sampled every six seconds, and is recorded to memory once every minute. If an interruption of power occurs during the minute between MFD memory write cycles, data sampled during that portion of a minute are not recorded.

3.2.1. MFD Data Recovery

The MFD compact flash card was undamaged and was read normally.

3.2.2. MFD Data Description

The MFD CF card contained 88 recording sessions, spanning from August 16, 2016, through and including the accident flight. Only the accident recording is considered in this report.

² CRT=+ means that for any parameter recorded that indicates a climb or a right turn, the sign for that value is positive. Also, for any parameter recorded that indicates an action or deflection, if it induces a climb or right turn, the value is positive. Examples: Right Roll = +, Left Aileron Trailing Edge Down = -, Right Aileron Trailing Edge Up = +, Pitch Up = +, Elevator Trailing Edge Up = +.

3.2.3. MFD Engineering Units Conversions

The data files downloaded from the MFD are in engineering units.

Appendix B lists the MFD parameters verified and provided in this report.

3.3. Time Correlation

PFD and MFD data were compared based on latitude and longitude to verify time alignment, and a discrepancy of approximately 1 hour and 9 minutes was identified. To establish a valid time reference, the Investigator-in-Charge supplied an air traffic control (ATC) recording of the accident flight's track.

An ATC position reported at 21:33:48 UTC (at 29°32'32.00"N, 98°26'45.00"W) was aligned with the following PFD and MFD coordinates:

- PFD: 29°32'30.80"N, 98°26'45.89"W
- MFD: 29°32'30.84"N, 98°26'40.92"W

Using this information, the following offsets were established to align the PFD and MFD to times recorded by ATC:

- PFD UTC = PFD recorded time + 01:18:54
- MFD UTC = MFD recorded time + 00:09:18

3.4. Tabular Data

PFD tabular data are provided as attachment 1. MFD tabular data are provided as attachment 2. Both attachments are in comma separated value (CSV) format.

APPENDIX A - PFD Parameters

This appendix describes the parameters provided and verified in this report. Table A-1 lists the PFD parameters and table A-2 describes the unit abbreviations used in this report for PFD parameters.

Table A-1 - Verified and provided parameters.

Parameter Name	Parameter Description
Accel Lat (g)	Lateral Acceleration
Accel Lat-Slip Skid (g)	Lateral Acceleration - Slip Skid Indication
Accel Long (g)	Longitudinal Acceleration
Accel Vert (g)	Vertical Acceleration
Active Course Valid (discrete)	Active Course Valid
AHRS goNoGo - Attitude Flag (discrete)	AHRS goNoGo - Attitude Flag
AHRS goNoGo - Bias Cutout Alarm (discrete)	AHRS goNoGo - Bias Cutout Alarm
AHRS goNoGo - Drift Alarm (discrete)	AHRS goNoGo - Drift Alarm
AHRS goNoGo - Heading Flag (discrete)	AHRS goNoGo - Heading Flag
AHRS goNoGo - Heading Rate Flag (discrete)	AHRS goNoGo - Heading Rate Flag
AHRS goNoGo - Lat Accel Flag (discrete)	AHRS goNoGo - Lateral Accel Flag
AHRS goNoGo - Need Fast Erect (discrete)	AHRS goNoGo - Need Fast Erect
AHRS goNoGo - Syn Rate Comp Alarm (discrete)	AHRS goNoGo - Syn Rate Comp Alarm
AHRS iruNoGo - Been Rebooted (discrete)	AHRS iruNoGo - Been Rebooted
AHRS iruNoGo - Cal Fail (discrete)	AHRS iruNoGo - Cal Fail
AHRS iruNoGo - Code Fail (discrete)	AHRS iruNoGo - Code Fail
AHRS iruNoGo - Reset (discrete)	AHRS iruNoGo - Reset
AHRS iruNoGo - Saturate (discrete)	AHRS iruNoGo - Saturate
AHRS iruNoGo - Temp Fail (discrete)	AHRS iruNoGo - Temp Fail
AHRS iruNoGo - Voltage Fail (discrete)	AHRS iruNoGo - Voltage Fail
AHRS magNoGo - Been Rebooted (discrete)	AHRS magNoGo - Been Rebooted
AHRS magNoGo - Cal Failed (discrete)	AHRS magNoGo - Cal Failed
AHRS magNoGo - Code Fail (discrete)	AHRS magNoGo - Code Fail
AHRS magNoGo - Field Strength (discrete)	AHRS magNoGo - Field Strength
AHRS magNoGo - Reset (discrete)	AHRS magNoGo - Reset
AHRS magNoGo - Temp Fail (discrete)	AHRS magNoGo - Temp Fail
AHRS mpuNoGo - Air Data Fail (discrete)	AHRS mpuNoGo - Air Data Fail
AHRS mpuNoGo - Erecting (discrete)	AHRS mpuNoGo - Erecting
AHRS mpuNoGo - IRU Dropout Sat Fail (discrete)	AHRS mpuNoGo - IRU Dropout Sat Fail
AHRS mpuNoGo - IRU Fail (discrete)	AHRS mpuNoGo - IRU Fail
AHRS mpuNoGo - IRU Temp Fail (discrete)	AHRS mpuNoGo - IRU Temp Fail
AHRS mpuNoGo - Mag Fail (discrete)	AHRS mpuNoGo - Mag Fail
AHRS mpuNoGo - Syn Rate Miscomp (discrete)	AHRS mpuNoGo - Syn Rate Miscomp
AHRS mpuNoGo - Tern Fail (discrete)	AHRS mpuNoGo - Tern Fail
Air Data goNoGo - Altitude Fail (discrete)	Air Data goNoGo - Altitude Fail

Parameter Name	Parameter Description
Air Data goNoGo - Amb Temp Alert (discrete)	Air Data goNoGo - Ambient Temperature Alert
Air Data goNoGo - IAS Fail (discrete)	Air Data goNoGo - Indicated Air Speed Fail
Air Data goNoGo - OAT Fail (discrete)	Air Data goNoGo - Outside Air Temperature Fail
Air Data goNoGo - TAS Fail (discrete)	Air Data goNoGo - True Airspeed Fail
Air Data goNoGo - VSI Fail (discrete)	Air Data goNoGo - Vertical Speed Indicator Fail
Airspeed Ind (kts)	Indicated Airspeed
Airspeed True (kts)	True Airspeed
Altitude Bug (ft)	Altitude Selector Bug
Altitude Press (ft)	Pressure Altitude
Altitude Rate (fpm)	Altitude Rate (Vertical Speed)
Baro Bug (inHg)	Display Barometric Correction Setting
DH Alert (discrete)	Decision Height Alert
Ground Speed (kts)	Ground Speed
Heading Mag (deg)	Magnetic Heading
Heading Bug (deg)	Heading Bug
IAS Bug (kts)	IAS Bug
Latitude (deg)	Latitude
Longitude (deg)	Longitude
Map Format (discrete)	Map Format
Map Range (discrete)	Map Range
Pitch (deg)	Pitch
Pitch Rate (deg/sec)	Pitch Rate
Roll (deg)	Roll
Roll Rate (deg/sec)	Roll Rate
Temp TAT (degC)	Temp TAT
Time - Day (day)	Time - Day
Time - Month (month)	Time - Month
Time - Year (year)	Time - Year
Time UTC Hrs (hr)	Time UTC Hrs
Time UTC Min (min)	Time UTC Min
Time UTC Sec (sec)	Time UTC Sec
Turn Rate (deg/sec)	Turn Rate
VSI Bug (fpm)	VSI Bug
Yaw Rate (deg/sec)	Yaw Rate

The PFD records pressure altitude, which is based on a standard altimeter setting of 29.92 inches of mercury (in Hg). The pressure altitude information presented in the plots and in the electronic data has not been corrected for the local altimeter setting at the time of the event.

Table A-2 - Unit abbreviations.

Units Abbreviation	Description
day	day
deg	degrees
deg/sec	degrees per second

Units Abbreviation	Description
degC	degrees Celsius
discrete	discrete
fpm	feet per minute
ft	feet
g	g
hr	hours
inHg	inches of Mercury
kts	knots
min	minutes
month	month
sec	seconds

NOTE: For parameters with a unit description of discrete, a discrete is typically a 1-bit parameter that is either a 0 state or a 1 state where each state is uniquely defined for each parameter.

APPENDIX B - MFD Parameters

This appendix describes the parameters provided and verified in this report. Table B-1 lists the MFD parameters.

Table B-1 - Verified and provided parameters.

Parameter Name	Parameter Description
ADJTIME UTC	Adjusted Time UTC
AMP1 (A)	Bus 1 Amps (amps)
AMP2 (A)	Bus 2 Amps (amps)
AMPB (A)	Battery Bus Amps (amps)
C# (degF)	Exhaust Gas Temperature Cylinder # ² (degrees Fahrenheit)
E# (degF)	Cylinder Head Temperature Cylinder # ³ (degrees Fahrenheit)
EBUS (V)	Essential Bus Voltage (Volts)
FF (gph)	Fuel Flow (gallons per hour)
LAT (deg)	Latitude (degrees)
LON (deg)	Longitude (degrees)
MAP (inHg)	Manifold Pressure (inches of mercury)
MBUS (V)	Main Bus Voltage (Volts)
OILP (psi)	Oil Pressure (pounds per square inch)
OILT (degF)	Oil Temperature (degrees Fahrenheit)
RPM (rpm)	Revolutions Per Minute (revolutions per minute)
TIME RAW	Time as recorded by MFD
USED (gal)	Fuel Used (gallons)

³ In the data plots the '#' is replaced with the appropriate cylinder ID from 1 to 6.